Fishery Data Series No. 05-10

A Mark-Recapture Experiment to Estimate the Spawning Escapement of Sockeye Salmon in the East Alsek River, 2003

By

David L. Waltemyer,

Daniel Reed,

Michael Tracy,

and

John H. Clark

March 2005

Alaska Department of Fish and Game Divisions of Sport Fish and Commercial Fisheries

Symbols and Abbreviations

The following symbols and abbreviations, and others approved for the Système International d'Unités (SI), are used without definition in the following reports by the Divisions of Sport Fish and of Commercial Fisheries: Fishery Manuscripts, Fishery Data Series Reports, Fishery Management Reports, and Special Publications. All others, including deviations from definitions listed below, are noted in the text at first mention, as well as in the titles or footnotes of tables, and in figure or figure captions.

Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
milliliter	mL
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
nautical mile	nmi
ounce	oz
pound	lb
quart	qt
yard	yd

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
degrees kelvin	K
hour	h
minute	min
second	s

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity (negative log of)	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

Alaska Department of Fish and Game	ADF&G
Alaska Administrative Code	AAC
all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.
all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.
at	@
compass directions:	
east	E
north	N
south	S
west	W
copyright	©
corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
District of Columbia	D.C.
et alii (and others)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.
Federal Information Code	FIC
id est (that is)	i.e.
latitude or longitude	lat. or long.
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S.C.	United States Code
U.S. state	use two-letter abbreviations (e.g., AK, WA)

Measures (fisheries)

fork length	FL
mideye-to-fork	MEF
mideye-to-tail-fork	METF
standard length	SL
total length	TL

Mathematics, statistics

all standard mathematical signs, symbols and abbreviations	
alternate hypothesis	H_A
base of natural logarithm	*e*
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	(F, t, χ^2, etc.)
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	*E*
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	log_2, etc.
minute (angular)	'
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
variance	
population	Var
sample	var

FISHERY DATA REPORT NO. 05–10

A MARK–RECAPTURE EXPERIMENT TO ESTIMATE THE SPAWNING ESCAPEMENT OF SOCKEYE SALMON IN THE EAST ALSEK RIVER, 2003

By
David L. Waltemyer,
Division of Commercial Fisheries, Soldotna,
Daniel Reed,
Division of Sport Fish, Fairbanks,
Michael Tracy,
Division of Commercial Fisheries, Yakutat,
And
John H. Clark,
Division of Commercial Fisheries, Juneau

Alaska Department of Fish and Game
Division of Commercial Fisheries
333 Raspberry Road, Anchorage, Alaska, 99518-1599

March 2005

Development and publication of this manuscript were partially financed by the Southeast Sustainable Salmon Fisheries Fund under Project 45215.

The Division of Sport Fish Fishery Data Series was established in 1987 for the publication of technically oriented results for a single project or group of closely related projects. Since 2004, the Division of Commercial Fisheries has also used the Fishery Data Series. Fishery Data Series reports are intended for fishery and other technical professionals. Fishery Data Series reports are available through the Alaska State Library and on the Internet: http://www.sf.adfg.state.ak.us/statewide/divreports/html/intersearch.cfm This publication has undergone editorial and peer review.

David L. Waltemyer
Alaska Department of Fish and Game, Division of Commercial Fisheries
43961 Kalifornsky Beach Road, Suite B, Soldotna, AK 99669-8367, USA

Daniel Reed
Alaska Department of Fish and Game, Division of Sport Fish
1300 College Road, Fairbanks, AK 99701-1599, USA

Michael Tracy
Alaska Department of Fish and Game, Division of Commercial Fisheries
PO Box 49, Yakutat, AK 99689-0049, USA

and

John H. Clark
Alaska Department of Fish and Game, Division of Commercial Fisheries
1255 W. 8th Street, PO Box 25526, Juneau, AK 99802-5526, USA

This document should be cited as:
Waltemyer, D. L., D. Reed, M. Tracy, and J.H. Clark. 2005. A Mark–Recapture Experiment to Estimate the Spawning Escapement of Sockeye Salmon in the East Alsek River, 2003. Alaska Department of Fish and Game, Fishery Data Series No 05-10, Anchorage.

TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ABSTRACT

This was the first year of a planned three-year study to estimate the abundance of sockeye salmon *Oncorhynchus nerka* returning to spawn in the East Alsek River located near Yakutat, Alaska. The abundance of sockeye salmon in 2003 was estimated using a two-event mark–recapture experiment. Biological data were collected during both sampling events. Fish were captured during Event 1 in the lower East Alsek River using a beach seine from July 9 through August 28. Each fish was marked by removal of the adipose fin and given a secondary batch mark in the form of an opercle punch or removal of an axillary appendage. A total of 3,223 sockeye salmon were captured, marked, and released during Event 1. In Event 2, fish carcasses were collected and examined for marks on the spawning grounds in three different sections of the river from September 23 through October 15. In Event 2, 3,954 sockeye salmon were sampled and of these, 103 were recaptures that had been previously marked in Event 1. After stratification of sample data into two size strata (less than or equal to 560 mm versus more than 560 mm) and using the Chapman's modification of the Petersen estimator, abundance of sockeye salmon in the East Alsek River in 2003 was estimated to total 122,037 fish (SE = 15,360). The peak aerial survey of sockeye salmon in the East Alsek River in 2003 was 31,000 fish on August 22. The expansion factor calculated from dividing the estimated escapement by the peak aerial survey count was 3.9 (SE = 0.49). The dominant age class represented in the 2003 escapement during Event 2 sampling was age-0.3 (88.6%, both sexes combined). Brood years from 1998 through 2000 contributed to the 2003 escapement. Freshwater age 0 fish represented more than 95% of the 2003 escapement.

Key words: sockeye salmon, *Oncorhynchus nerka*, spawning abundance, East Alsek River, mark–recapture, peak survey count, expansion factor, age, sex, length composition, Yakutat, Alaska

INTRODUCTION

The East Alsek River system is located approximately 75 km southeast of Yakutat, Alaska (Figure 1). The East Alsek River was formed when the glacially occluded trans-boundary Alsek River changed channels about a century ago. The Alsek River now enters the ocean about 4.8 km to the northwest of the mouth of the East Alsek River. Inter-gravel flow from the glacially occluded Alsek River feeds clear water through a gravel berm into the East Alsek River. Hence, the East Alsek River is simply a portion of the old Alsek River channel with clear running water and no direct interconnection with the Alsek River itself. The Alsek River is a large river system draining approximately 20,400 km^2 including portions of the Yukon Territory in Canada and the southeastern Alaska panhandle. The East Alsek River has a small drainage area and is only about 15 km in length before entering an estuary lagoon and the Gulf of Alaska.

Early in the 20th century, anadromous salmon invaded the newly created clear waters of the East Alsek River thus utilizing the river's unique spring-type habitat for spawning and rearing phases of their life history. The East Alsek River provides spawning and rearing habitat for sockeye salmon *Oncorhynchus nerka,* coho salmon *O. kisutch*, chum salmon *O. keta*, and pink salmon *O. gorbuscha* stocks that are commercially utilized as well as supporting minor subsistence and sport fisheries. The East Alsek River was not a major sockeye salmon producing river system; it was primarily considered to be a chum salmon producer. During latter parts of the fall season, runs of coho salmon returning to the river system were also harvested.

Historically, small family groups of commercial fishermen made wages on the sockeye salmon run, and were later joined by other commercial fishermen for the larger chum salmon fishery. From 1947 through 1970, the highest annual commercial catch reported for sockeye salmon was 17,000 fish in 1954, and from 1956 through 1968, the highest catch was 6,500 sockeye salmon in 1962. In most years, sockeye salmon harvests did not exceed 3,000 fish. It was not until the late 1970's and early 1980's that sockeye salmon catches started climbing exponentially. Commercial harvests of sockeye salmon in the East Alsek set gill net fishery averaged about 22,000 fish in the 1970's, about 90,000 fish in the 1980's, about 120,000 fish in the early 1990's, and dropped to about 20,000 fish in the late 1990's. Peak annual harvests in excess of 180,000 sockeye salmon occurred in 1986 and 1993. From the mid-1990s to the present, the numbers of returning

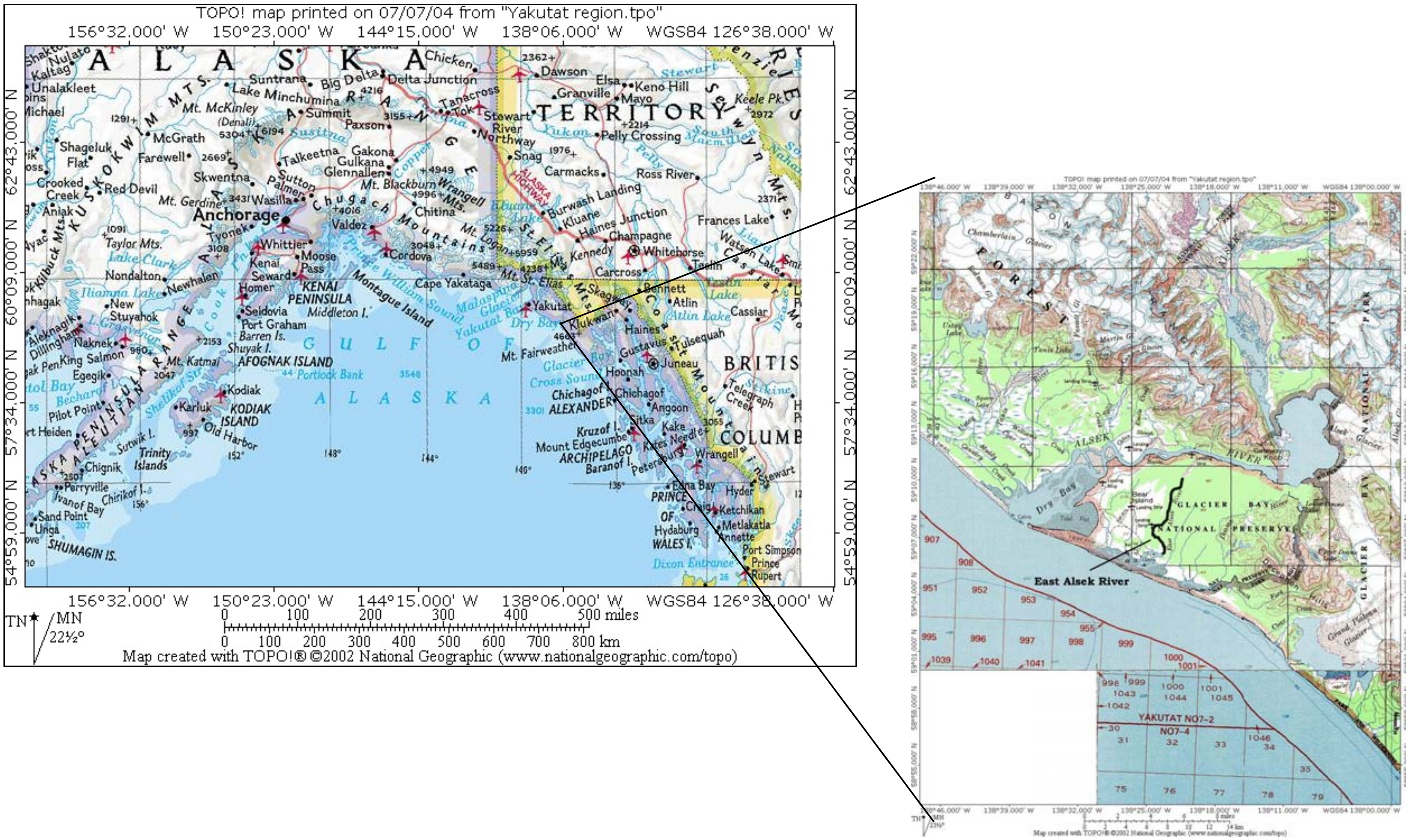

Figure 1.– Map showing location of the East Alsek River southeast of Yakutat, Alaska.

sockeye salmon dropped to the point that there was not a commercial opening for sockeye salmon in the East Alsek fishery from 1999–2001.

Sockeye salmon use the East Alsek River system for spawning, but only for very short-term rearing. The river, with its crystal clear water, favorable water temperatures, excellent substrate, and favorable flows provided exceptional spawning habitat through the 1970's and 1980's. As a result, the sockeye salmon stock quickly grew to a quarter million fish in some years. The stock is unique in that a large majority of the East Alsek River sockeye salmon are "zero checks". These fish migrate to sea the year they hatch, more similar in life history patterns to chum and pink salmon, rather than to typical sockeye salmon that rear in fresh water for one to three years after hatching. Adaptation of sockeye salmon to this unique life history characteristic and the exceptional spawning habitat in the East Alsek River allowed this stock to explode from the mid-1970s through the early 1990s.

These available data demonstrates an approximate 25-year sockeye salmon "event". The joining of the East Alsek River and the Doame River waters in 1966 is a likely contributing factor that added a large amount of rearing habitat in the lagoon. Basically, the lagoon provides some of the function of a lake as found in more traditional sockeye salmon producing systems. An earthquake in 1959 was likely responsible for several phenomena that resulted in (1) the eastward shift of portions of the Alsek River channel, (2) tectonic plate movement including upheaval, and (3) the expansion of Alsek Lake from glacial fracture and retreat. Flow of the Alsek River shifted from a westerly to an easterly course. An examination of the geography of the Yakutat area shows that all rivers in the Yakutat area to the southeast of the Tsiu River[1] empty into the Gulf of Alaska to the west. Some of these rivers, like the East Alsek River and the Akwe River, flow westward inside the beach for several miles before actually emptying into the ocean. With the Alsek River migrating eastward, more water was potentially available for flowing into the East Alsek River. With elevated channelization of the Alsek, the extent that flood stage would be attained at less extreme water levels would produce a condition that would prevail until the Alsek River channel had been lowered through normal channel attrition. The expansion of Alsek Lake would promote deposition of water-borne sediments in the lake and accelerate channel attrition downstream. This phenomenon usually occurs when a reservoir is created by the imposition of a dam; sediment deposition upstream and channel incisement downstream. The Alsek River channel below the lake is now well incised and reaches bedrock in some places.

More important were major flood events in the Alsek River itself. From 1964 to 1983, there were four major flood events in the Alsek River. During each of these flood events, the Alsek River overflowed its banks and poured down the East Alsek River. These flood events scoured the spawning gravel and cleaned out the emergent vegetation growing in the East Alsek River. The last time the Alsek River overflowed its banks and flooded the East Alsek River was in 1981 and it was a minor event lasting about 24 hours. In 1997, the Alsek River had a 100-year flood event. No one in living memory had seen the Alsek River so high, and it took out a cabin that had been on the river for over 60 years. That flood did not overflow into the East Alsek River. Even the 2002 record volume of 178,000 cubic feet per second didn't crest the banks and flood the East Alsek River. No subsequent flood in the Alsek River has overflowed and scoured the East Alsek River, because the Alsek River by the early 1980's had resumed its migration to the west. East Alsek commercial fishermen now must contend with algae produced on the sockeye salmon spawning grounds in the upper East Alsek River. Even on an incoming tide, fishermen have to continuously shake their net to clean it, and the river is impossible to fish on an outgoing tide. As soon as the tide turns, all nets are wrapped up to the cork line to allow the algae to pass freely under the net. The East Alsek River, even in flood stage, is not powerful enough to scour the algae. It takes the physical force of an overflowing Alsek River to scour the emergent vegetation out of the East Alsek River. For the past decade, the upper East Alsek River has been choked with vegetation, and

[1] In the Yakutat Management Area, the Tsiu River is the river located the farthest northwest in the area.

it is estimated that 60% of the spawning gravel is no longer available to sockeye salmon.

Thus, we believe that the major factor responsible for the East Alsek River 25-year sockeye salmon "event" was the periodic (about every 5 years) flushing of the gravel beds in the East Alsek River by flood events from the much larger trans-boundary Alsek River. The last flood event of this type occurred in 1981 and by the early 1990's, the spawning habitat of the East Alsek River had deteriorated considerably. Although sockeye salmon escapements in the early 1990's were predicted to provide for excellent production, those escapements produced far fewer recruits than expected in subsequent years. Emergent vegetation and the siltation of the gravel beds have greatly deteriorated the quality of the spawning habitat. Thus, the history of sockeye salmon production in the East Alsek River includes the following:

1. invasion in the early 1900s,
2. adaptation to the environment with development of a subsequent unique life history feature,
3. population explosion in the 1970s and 1980's, and
4. lesser abundance since the early 1990s due to deteriorating spawning habitat.

The on-going stock assessment program for the East Alsek–Doame River system consists of flying aerial surveys of both the East Alsek River and the Doame River to count spawners, collecting and tabulating fish tickets and subsistence catch reports, and monitoring of the sport fishery through a postal questionnaire. Annual sampling of the commercial catch and periodic annual sampling of the East Alsek River escapement for age, sex, and length information also has taken place.

While the commercial fishery is actively managed, a more passive management (fishery monitoring) of the subsistence and sport fisheries has typically occurred since statehood. Run timing for the two sockeye salmon spawning populations has been considered different, with Doame River sockeye salmon entering the terminal fishery from early June through mid-July, and East Alsek River sockeye salmon entering the fishery from late July into September. Active management of the commercial fishery consists of weekly aerial surveys of spawning escapements and variable openings of the commercial fishery on a weekly basis. In many years, the East Alsek River commercial fishery was either curtailed or closed during the early weeks to provide additional protection for the smaller Doame River sockeye salmon population. In those years, the more dominant East Alsek River sockeye salmon population was exploited later in the season. The commercial harvest of less than 6,000 sockeye salmon in 1998 represented the smallest harvest since the population explosion of the 1970's and 1980's. Commercial openings for sockeye salmon did not occur from 1999–2001. In 2001, the sport fishery for sockeye salmon was also closed through emergency order. Commercial harvesting was allowed in 2002 and in 2003.

In 1995, the Alaska Department of Fish and Game (ADF&G) adopted an escapement goal of 26,000 to 57,000 sockeye salmon counted during a peak survey of the East Alsek–Doame River system on an annual basis (Clark, Burkholder, and Clark, 1995). Data used in this analysis was primarily from the 1970's and 1980's when the population was at very high levels. By the late 1990's, it became apparent that productivity of the stock had significantly declined and the issue of the appropriateness of the existing escapement goal for this stock came into question. Stock–recruit analysis in the fall of 2002 confirmed that a significant drop in productivity had occurred. In the spring of 2003, ADF&G revised the escapement goal to 13,000 to 26,000 sockeye salmon counted during a peak survey of the East Alsek–Doame River system on an annual basis (Clark et al. 2003). In addition to a reduction in the escapement goal for the stock, the authors recommended that research be funded to estimate total abundance of sockeye salmon in the East Alsek River with the intent to determine what portion of that total abundance is represented by peak aerial counts. Further, they recommended these efforts be maintained for a minimum of three years so annual variation in peak aerial surveys could be documented.

In the fall of 2002, funding was obtained from the Southeast Sustainable Salmon Fisheries Fund (SSSF) to augment stock assessment information for management of sockeye and coho salmon fisheries in the Yakutat Area. An important aspect of this overall stock assessment effort was to provide improved information concerning abundance of sockeye salmon returning to the East Alsek River system. This report documents work intended to estimate abundance of sockeye salmon in the East Alsek River in 2003. Specific objectives for East Alsek River sockeye salmon stock assessments in 2003 were: (1) estimate the total number of sockeye salmon in the East Alsek River; (2) estimate the expansion factor (escapement estimate divided by the peak survey count); and (3) estimate the age and sex composition of the escapement of sockeye salmon in the East Alsek River.

METHODS

A two-event mark–recapture experiment for a closed population (Seber 1982) was conducted to estimate abundance of sockeye salmon in the East Alsek River in 2003.

CAPTURE AND MARKING (EVENT 1)

Immigrating sockeye salmon were caught above the upper boundary of the East Alsek commercial set gillnet fishing district in an area known as "the lake". A 60 m x 4 m (mesh 2.2 cm) beach seine was used to capture fish during Event 1 from 9 July to 28 August. The number of beach seine sets each day and the resultant catch per set were recorded on field data forms.

Upon retrieval of the beach seine, sockeye salmon were carefully removed from the net for sampling. Sockeye salmon captured and in good condition were measured from mid-eye to fork of tail (MEF) to the nearest 5 mm, doubly marked, and released. The primary mark was an adipose fin clip. The secondary mark was:

1. removal of the left axillary process (LAUX) if the fish was caught from 9 July through 15 July.
2. removal of the right axillary process (RAUX) if the fish was caught from 23 July through 30 July.
3. a 6 mm diameter hole punched in the upper one-third of the left opercle (LUOP) with a paper punch if the fish was caught from 4 August through 6 August.
4. a 6 mm diameter hole punched in the upper one-third of the right opercle (RUOP) with a paper punch if the fish was caught from 13 August through 19 August.
5. two 6 mm diameter holes, one punched in the upper one-third of the right opercle (RUOP) and the other punched in the upper one-third of the left opercle (LUOP) if the fish was caught from 26 August through 28 August.

The secondary marks were used to ensure that when a fish was examined on the spawning grounds the time period when the fish was marked and released could be determined. Further, this ensured that we could conduct appropriate tests of the data when calculating the mark–recapture estimate. The condition of each fish was assessed, noted, and recorded. Fish with deep wounds, damaged gills or fish in a lethargic condition were released without being marked.

RECOVERY ON SPAWNING GROUNDS (EVENT 2)

Event 2 sampling was conducted by collecting and inspecting sockeye salmon carcasses for marks throughout the spawning grounds of the East Alsek River. In order to assess mixing of marked and unmarked segments of the spawning population, the East Alsek River was split into three sections with entry at approximately 2.4 km, 4.8 km, and 11 km upriver on the spawning grounds. The numbers of marked and unmarked fish examined during Event 2 sampling in these three sections of river were discretely recorded and compared to determine if marking rates were relatively constant across the entire spawning grounds. Sampling crews of 2 to 4 persons walked the East Alsek River spawning grounds and gathered carcasses between 23 September and 15 October. Once a fish was examined, a slash mark was made on the left side of the fish to ensure that these fish were not sampled again.

ABUNDANCE ESTIMATION

We used Chapman's modification of the Petersen Method (Seber 1982) to estimate abundance of the sockeye salmon escapement in each of two size strata:

$$\hat{N}_s = \frac{(M_s + 1)(C_s + 1)}{(R_s + 1)} - 1 \qquad (1)$$

where:

$\hat{N}_s$ = estimated abundance of sockeye salmon in size stratum s;

M_s = number of marked sockeye released in event 1 in size stratum s;

C_s = number of sockeye carcasses in size stratum s inspected for marks during event 2; and

R_s = number of sockeye carcasses in size stratum s with marks in samples during event 2.

The conditions for accurate use of this methodology are:

1. all sockeye salmon have an equal probability of being marked; or
2. all sockeye salmon have an equal probability of being inspected for marks; or
3. marked fish mixed completely with unmarked fish between events; and
4. there is no recruitment to the population between events; and
5. there is no mark-induced mortality; and
6. fish do not lose their marks and all marks are recognizable.

Meeting the first condition depended upon entry pattern, how long these fish remained in the area where netting occurred, and the fishing effort that took place during event 1. Residence time at the first event sampling site is unknown and only limited inference can be gleaned concerning entry pattern based on catch per unit effort statistics during event 1 sampling. Event 1 sampling effort was sporadic with anywhere from 0 to 8 beach seine sets per day over a 51 day period of time. Meeting the second condition depended primarily upon survey coverage. Second event sampling took place over a 23 day period and throughout the spawning grounds. Meeting the third condition depended primarily upon behavior of fish marked during event 1.

Three consistency tests described by Seber (1982) were used to test for temporal and/or spatial violations of conditions 1–3. Contingency table analyses were used to test three null hypotheses: (1) the probability that a marked fish was recovered during Event 2 was independent of when it was marked; (2) the probability that a fish that was inspected during Event 2 was marked was independent of when/where it was caught during the second event; and (3) for all marked fish recovered during Event 2, time of marking was independent of when/where recovery occurred. Failure to reject at least one of these three hypotheses is sufficient to conclude that at least one of conditions 1–3 was satisfied.

Assumptions 1–3 could also be violated if length or sex selective sampling occurred. Meeting these conditions was tested through a series of hypothesis tests (Appendix A1). Determination of whether the sockeye salmon sampled in Event 1 had similar length distributions to fish sampled in Event 2 was based upon the Kolmogorov-Smirnov (K-S) test. The test hypothesis was that fish of different lengths were captured with equal probability using the test criterion level of $\alpha = 0.1$.

The basis for meeting assumption 4 (no recruitment) is based entirely on prior observations. During aerial surveys of the East Alsek River, newly arriving sockeye salmon have not been observed in September. Further, catches of sockeye salmon in the commercial fishery after August quickly decline and instead coho salmon are harvested. Consequently, we believe that little or no recruitment to the population occurred following completion of event 1 sampling.

Anytime salmon are caught and handled, there is potential for mark-induced mortality (condition 5). Periodic visual examinations of the area where event 1 sampling occurred failed to document dead marked sockeye salmon. However, this provides only limited testing of this important assumption. In 2004, this assumption was tested through the application and tracking of radio-tagged sockeye salmon. Preliminary analysis indicates that radio-tagged sockeye salmon recruited successfully to the spawning grounds of the East Alsek River.

Each marked fish received a primary mark and a secondary mark to insure that marks were recognizable during second-event sampling. Thus marked fish were unable to lose their marks as sometimes occurs with tagged fish (condition 6).

Estimates of the variance for $\hat{N}_s$ were obtained through bootstrapping (Efron and Tibshirani 1993) according to methods in Buckland and Garthwaite (1991). The fate of the estimated $\hat{N}_s$ in the experiment was divided into capture histories (Table 1) to form an empirical probability distribution (*epd*). A bootstrap sample of size $\hat{N}_s$ was drawn from the *epd* with replacement. From the resulting collection of resample capture histories, R_s^*, C_s^*, $\hat{M}_s^*$, and $\hat{N}_{b,s}^*$ was calculated. One million bootstrap samples were drawn.

Table 1.–Fates of sockeye salmon in the mark–recapture experiment.

Marked and never seen again
Marked and recaptured on spawning grounds
Unmarked and never seen on the spawning grounds
Unmarked and inspected on the spawning grounds

The approximate variance was calculated as:

$$\mathrm{var}(\hat{N}_s) = \frac{\sum_{b=1}^{B} (\hat{N}_{b,s}^* - \hat{\bar{N}}_s^*)^2}{B-1} \qquad (2)$$

where $\hat{\bar{N}}_s^*$ is the average of the $\hat{N}_{b,s}^*$.

Total abundance, $\hat{N}$, was estimated as the sum of stratum abundance estimates and the variance of the total abundance estimate was calculated as the sum of variances across strata.

Aerial Survey to Total Escapement Expansion Factor

The expansion factor for the peak count of sockeye salmon from the survey in 2003 and its variance was estimated as follows:

$$\hat{\pi}_{2003} = \hat{N} / I_{2003} \qquad (3)$$

$$var(\hat{\pi}_{2003}) = var(\hat{N}) I_{2003}^{-2} \qquad (4)$$

where π_{2003} was the true expansion factor for 2003 and I_{2003} the peak count of several surveys conducted in 2003. The variance in equation 4 represents sampling-induced variation from the mark–recapture experiment, and accordingly represents the same precision attained with the estimate of abundance from that experiment.

Age, Sex, and Length Composition

Scales were collected from 559 sockeye salmon sampled during Event 2. Fish scales were taken from the left side of the salmon approximately two rows above the lateral line on the diagonal row that extends down from the posterior insertion of the dorsal fin to the anterior insertion of the anal fin (Koo 1955). Scales were mounted on gum cards and impressions made in cellulose acetate as prescribed by Clutter and Whitesel (1956). Ages of sockeye were determined by visual examination of scale impressions under moderate magnification (40X) using a microfiche viewer. Age was determined based on criteria established by Mosher (1969). Ages were recorded in European notation (Koo 1962). Sex and length were recorded for all specimens sampled. Sex of the fish was determined by morphological characteristics. Length in millimeters was measured from mid-eye to fork-of-tail (MEF) in 5 mm increments.

For each size strata, age and sex composition was estimated as a series of proportions p_{ij} defining a multinomial distribution. The marginal proportion was estimated for each combination of age and sex along with estimates of the proportions' variance (Cochran 1977):

$$\hat{p}_{ij,s} = n_{ij,s} / n_s \qquad (5)$$

$$\mathrm{var}(\hat{p}_{ij,s}) = \frac{\hat{p}_{ij,s}(1-\hat{p}_{ij,s})}{n_s - 1} \qquad (6)$$

where n_s was the sample size from stratum s and $n_{ij,s}$ the number in the sample of age *i* sex *j*.

The estimated total escapement of salmon for age *i* sex *j* was calculated:

$$\hat{N}_{ij} = \sum_{s=1}^{2} \hat{p}_{ij,s} \hat{N}_s \qquad (7)$$

with variance (Goodman 1960):

$$\mathrm{var}(\hat{N}_{ij}) = \sum_{s=1}^{2} \mathrm{var}(\hat{p}_{ij,s}) \hat{N}_s^2 + \mathrm{var}(\hat{N}_s) \hat{p}_{ij,s}^2 \qquad (8)$$

The estimated proportion of the total escapement for age *i* sex *j* was calculated:

$$\hat{p}_{ij} = \hat{N}_{ij} \Big/ \hat{N} \quad (9)$$

with variance of the estimated proportion was approximated with the delta method (Seber 1982):

$$\mathrm{var}(\hat{p}_{ij}) = \sum_{s=1}^{2} \mathrm{var}(\hat{p}_{ij,s})(\hat{N}_s / \hat{N})^2 + \hat{N}^{-2} \sum_{s=1}^{2} \mathrm{var}(\hat{N}_s)(\hat{p}_{ij,s} - \hat{p}_{ij})^2 \quad (10)$$

Length composition was estimated using stratified random sampling methods weighted by stratum escapement for each combination of age and sex with estimates of the mean length's variance (Cochran 1977).

RESULTS

TAGGING, RECOVERY AND ABUNDANCE

A total of 3,224 sockeye salmon were captured, sampled and released with primary and secondary marks between 9 July and 28 August 2003 (Table 2, Appendix A2). During the entire marking event, only one fish was observed to have died as a direct result of the marking operation. Any fish that were not in "good" condition for release were not marked nor included in the marked sample. Thus, a total of 3,223 fish were considered viable marked fish in Event 1.

Table 2.–Number of sockeye salmon marked in Event 1 and inspected for marks on the spawning grounds by location in Event 2, East Alsek River, 2003.

Event 1:		
Released with marks (M)	3,224	
1 direct mortality, adjusted Total		3,223
Event 2:		
Captured (C)		
Lower Section	1,051	
Middle Section	1,966	
Upper Section	937	
Total		3,954
Recaptured (R)		
Lower Section	31	
Middle Section	46	
Upper Section	26	
Total		103

From 23 September through 15 October of 2003, a total of 3,954 fish from the lower, middle and upper sections of the East Alsek River were inspected during Event 2 (Table 2, Appendix A3). Of these, 103 fish were observed with marks. All marked fish had their primary adipose fin clip.

Integral to the structural integrity of the abundance estimate, testing for size bias sampling was conducted. Statistical differences in length frequency of marked fish and subsequently inspected marked and unmarked fish was accomplished. Length frequencies were plotted and found to differ statistically between fish marked in Event 1 and those marked fish recaptured on the spawning grounds in Event 2 (K-S = 0.359, p<0.001; Figure 2A). Similarly, length frequency distributions differed statistically for all fish marked (M) during Event 1 and those captured (C) during Event 2 (K-S = 0.353, p<0.001;Figure 2B). However, there was no significant difference between length frequencies for all fish captured (C) and recaptures (R) in Event 2 (K-S = 0.05, p = 0.97). Based on these tests, we had a Case IV experiment (see Appendix A1) and needed to stratify our data by size and then estimate abundance for each size stratum independently. Diagnostics for splitting the size groups into two strata was determined as the greatest difference in the cumulative density functions for both the M-R and M-C fish and occurred at 560 mm. Testing for size bias sampling within these two strata was also conducted (Table 3). The null hypothesis of no differences in size distributions of M-R was accepted for fish measuring less than or equal to 560 mm (K-S = 0.073, p = 0.847). For the M-C test in this same size category, the K-S test statistic was 0.109 with a p value of <0.001, so we rejected the null hypothesis of no size differences. This left us with a Case II experiment for this stratum. The K-S test statistic for M-R fish measuring greater than 560 mm was K-S = 0.074 with a p value <0.996. Thus, the null hypothesis was accepted for the distributions of marked and recaptured fish. However, the K-S test statistic for the M-C fish was 0.122 with a p value of <0.001, so we rejected the null hypothesis. This left us with a Case II experiment for this stratum. Therefore, it was necessary to stratify our data by length and then estimate abundance for each length category.

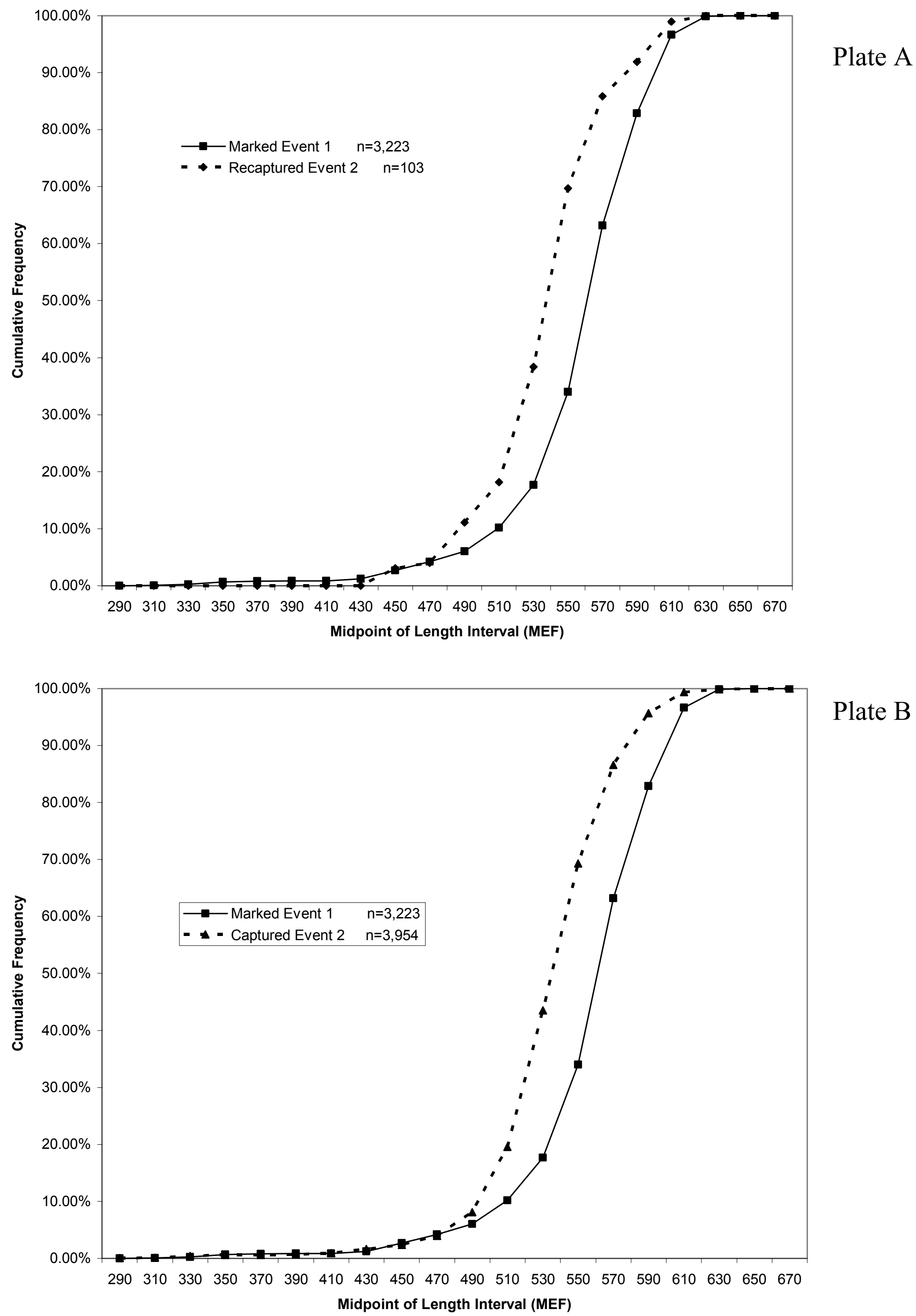

Figure 2.– Cumulative length frequencies of sockeye salmon marked in Event 1 compared to recaptured (Plate A) and overall captured (Plate B) fish in Event 2 (all river sections combined) in the East Alsek River, 2003.

Table 3.– Summary of Kolmogorov-Smirnov (K-S) test results for size frequency distributions observed in marked (M), captured (C), and recaptured (R) samples.

Size Category	K-S Statistic	Probability Level	Hypothesis Test
Less than or equal to 560 mm			
M-R	0.073	0.847	Accept
M-C	0.109	<0.001	Reject
Greater than 560 mm			
M-R	0.074	0.996	Accept
M-C	0.122	<0.001	Reject

Diagnostics were directed at evaluating if at least one of the first three "or" assumptions of the estimator were satisfied. We tested the null hypothesis that the probability of a fish being inspected for marks was independent of the time during the run that it was marked in Event 1. The Chi-square (χ^2) Test statistic was 1.038 with a p value of 0.595, thus we failed to reject the null hypothesis and no temporal stratification was necessary. A second temporal test was conducted for testing the null hypothesis that the probability that an Event 2 fish was marked was independent of the time (September or October) during Event 2 when the fish was caught and inspected. The χ^2 was equal to 0.974 with a p value of 0.324, so we failed to reject the null hypothesis. A third χ^2 Test was conducted for testing the null hypothesis that the probability of an Event 2 fish was marked was independent of the time during Event 2 when the fish was caught and inspected during four time periods on the spawning grounds. The χ^2 test statistic was 2.021 with a p value of 0.568 and again we failed to reject the null hypothesis. In addition, we tested the null hypothesis that the probability that an Event 2 fish was marked was independent of where in the river (lower, middle, or upper sections) it was caught and inspected. The χ^2 statistic was 1.143 with a p value of 0.565, so again we failed to reject the null hypothesis. Therefore, no temporal and spatial stratifications were necessary in Event 2.

The estimates of abundance based on stratifying by the under and over 560 mm size categories for our altered model were 41,174 and 80,863 fish respectively for a total abundance estimate of 122,037 fish (SE = 15,360). The 95% CI is 99,320 to 159,300 fish based on the bootstrap analysis. The estimate of escapement using the unaltered (biased) model was 122,604 fish (SE = 11,615). The 95% CI is 99,839 to 145,369 fish based on the unaltered model.

EXPANSION FACTOR

During 2003, there were 10 aerial surveys of the East Alsek River wherein sockeye salmon were counted (Table 4). The peak survey occurred on August 22 and the count was 31,000 sockeye salmon. The expansion factor for the 2003 East Alsek River sockeye salmon aerial surveys was calculated as the ratio of the estimate of abundance of sockeye salmon to the peak aerial survey count. The estimated expansion factor for 2003 was 3.9 (SE = 0.49).

Table 4.– Summary of aerial surveys conducted and number of sockeye enumerated in the East Alsek River, 2003.

Date	Count	Criteria[a]
6/9	1,200	
6/23	3,600	
6/30	3,500	
7/7	5,300	
7/16	3,000	visibility effected
7/18	7,500	
8/1	16,000	
8/7	14,800	
8/22	31,000	visibility excellent
9/6	30,000	visibility normal

[a]Visibility factors would include: observer, time of day, shadows on water, surface water disturbance from rain and wind.

ESTIMATES OF AGE, SEX AND LENGTH COMPOSITION

The age composition of fish sampled in the East Alsek River was comprised of six age classes ranging from age-0.2 to age-2.2 that represented three brood years (2000, 1999, and 1998) that returned in 2003 as 3, 4 and 5 year old fish (Table 5). The predominant age class (both sexes combined) was age-0.3 (88.6%). Age-0.2 (6.4%), age-1.3 (3.6%), age-1.2 (1.2%), age-0.4 (0.1%), and age-2.2 (0.1%) composed the remainder. Overall males represented 50.7% and females represented 49.3% of the escapement. However, in the size category of fish less than or equal to 560 mm, males represented 15.3% and females represented 84.7% (Appendix A4). In the size category of greater than 560 mm, males represented 68.6% and females were 31.4% of the sample.

Average length composition by age for all strata combined in the escapement ranged from 493 mm for age-1.2 to 575 mm for age-1.3 (Table 5). Overall average length for males was 586 mm and for females was 552 mm.

DISCUSSION

The appropriateness (lack of bias) of using an abundance estimator such as the Chapman modification of the Petersen estimator is based on meeting several necessary conditions. We collected data so we could directly evaluate the three "or" assumptions and demonstrated through a series of statistical tests the scientific appropriateness of the estimate derived from the perspective of the three "or" assumptions.

Likewise, we were careful to ensure we addressed assumption 6 (recognizable marks). Four of the 3,954 sockeye salmon examined during the second event had adipose clips, but not secondary marks. Review of the data collection during event 1 sampling identified several adipose clipped fish had escaped before secondary marks were applied by the sampling crew. This confirmed that these fish with missing adipose fins were in fact, valid recaptures but whose time of marking was indiscernible. These four fish were incorporated into the estimation process. Protocols for fin clipping

Table 5.– Age and length composition and estimated escapement by age class for the East Alsek River sockeye salmon, 2003.

	Age[a]						
Parameter	0.2	0.3	1.2	0.4	1.3	2.2	Total
Combined length strata							
Female							
Sample size	47	260	7	1	14		329
Escapement estimate	6,047	51,343	901	129	1,801		60,221
SE[b] Escapement estimate	1,052	5,968	350	129	509		6,458
% Escapement	5.0%	42.1%	0.7%	0.1%	1.5%		49.3%
SE % Escapement	0.9%	2.8%	0.3%	0.1%	0.4%		3.4%
Mean Length[c]	507	558	503	525	544		552
SE Length	3	1	5		3		1
Male							
Sample size	14	149	4		8	1	176
Escapement estimate	1,801	56,800	515		2,571	129	61,816
SE Escapement estimate	509	9,536	261		1,047	129	9,907
% Escapement	1.5%	46.5%	0.4%		2.1%	0.1%	50.7%
SE % Escapement	0.4%	3.5%	0.2%		0.8%	0.1%	3.4%
Mean Length	504	590	475		590	555	586
SE Length	9	1	11		5		1
Combined							
Sample size	61	409	11	1	22	1	505
Escapement estimate	7,849	108,143	1,415	129	4,373	129	122,037
SE Escapement estimate	1,251	13,875	446	129	1,170	129	14,520
% Escapement	6.4%	88.6%	1.2%	0.1%	3.6%	0.1%	100.0%
SE % Escapement	1.1%	1.6%	0.4%	0.1%	0.9%	0.1%	0.0%
Mean Length	506	575	493	525	571	555	569
SE Length	3	1	5		3		1

[a] Size stratified estimates of age and length composition and escapement by age class for East Alsek River sockeye salmon are presented in Appendix A4.
[b] SE - standard error of estimate
[c] Mean Length - represents the mean of 5 mm interval measurements.

will be altered to alleviate this problem by applying the opercle punch or axillary fin clip first and then the adipose fin clip.

We believe that assumption 4 (no recruitment) was met for several reasons. Recruitment through growth was not possible. Recruitment was only a possibility if fish entered the system before or after event 1 sampling and died and disappeared before event 2 or died after event 2. We attempted to implement event 1 sampling across a relatively long time period (51 days) that coincided with the time period in previous years when sockeye salmon were caught in the commercial fishery located just downstream from our sampling site. Daily seine catches started out low at the beginning and gradually built up to a peak on 18 August and then gradually decreased by the end of our sampling regime confirming that sampling was conducted throughout the majority of the immigration. Also, fish condition changed over the course of the sampling regime. At the start, most fish were bright. As the sampling schedule progressed, fish condition changed from bright to increasing proportions that were blush and eventually red indicating that the end of the run was imminent. Event 2 sampling occurred over a 23 day period. Few fish were observed dying before the start of event 2 and few live fish were observed at the end of event 2. Hence, we believe it highly unlikely that the abundance estimate derived in 2003 is biased due to recruitment.

Marked fish may have had a greater mortality rate than unmarked fish (assumption 5) because catching, handling and marking sockeye salmon may induce mortality or delay their upstream migration. A commercial fishery occurred in the East Alsek River District in 2003 with a relatively small harvest of 2,617 sockeye salmon. The sockeye salmon caught were not carefully inspected for the presence of marks. There was a single voluntary report of a marked fish being caught, but unfortunately the mark type was not noted. The information was of little use to answer the question whether the portion of marked fish in the catch was disproportional. The question whether marked fish suffered a higher mortality rate than sockeye salmon that were not caught and handled could not be directly compared. However, we examined sockeye salmon that were found dead during Event 1. There was only one marked fish found, thus differential mortality was considered inconsequential to the estimation process. Further, work implemented with radio tags in 2004 indicates that sockeye salmon marked at the first event sampling site successfully recruited to the spawning grounds, providing some additional evidence that the 2003 estimate is not biased due to concerns with assumption 5.

Analysis of data collected in 2003 indicated that size biased sampling occurred. However, comparison of the estimates derived when taking length biased sampling data into account indicated that the bias in the overall estimate was negligible.

We believe that the abundance estimate of 122,037 sockeye salmon derived from the mark–recapture experiment in 2003 is a relatively unbiased estimate of the actual abundance of sockeye salmon that returned to the East Alsek River in 2003. As a result, the portion of sockeye salmon observed during the peak aerial survey was approximately 25% of the actual abundance. This value is considerably lower than was previously thought. Prior opinions concerning this proportion generally centered on the belief that the peak aerial surveys accounted for about two-thirds of the total (Clark et al. 2003).

Age composition information collected in 2003 suggests similarities to past escapements (Clark, et al. 2003). The Age-4 component of the escapement has continued to be the predominant age group, but there has been a shift of the age-3 and age-5 components depending on year.

CONCLUSIONS AND RECOMMENDATIONS

Estimating the total escapement is important information for assessment and management of the East Alsek sockeye salmon stock. Use of a two-event mark–recapture abundance estimator provided an accurate and precise estimate of 122,037 fish as the estimated abundance for the 2003 escapement of sockeye salmon in the East Alsek River. The peak aerial survey of 31,000 on 22 August in 2003 represented about 25 % of the actual abundance of sockeye salmon in the East Alsek River. Brood years 1998 to 2000 contributed to the 2003 run.

Multiple years are critical to determining annual variation and an appropriate average for application of expansion factors to historic peak aerial surveys for run reconstruction efforts. At least three years of useable abundance estimates and companion expansion factors should be collected. This would provide the data needed to improve historic run reconstructions and improve information relative to productivity and estimation of an appropriate escapement goal for this stock of salmon.

ACKNOWLEDGMENTS

We thank Alyssa Caracciolo, Matt Caterson, Ann Crane, Mike Freeman, Nicole Miller, and Greg Vaughn for conducting the field work and data collection while operating from the Dry Bay/East Alsek field camp. We thank Gordon Woods for providing support and logistics associated with the field work. Gordon Woods and Mike Freeman conducted aerial surveys for this study. Iris Frank completed the aging of sockeye salmon scales collected during the project. We thank Ted Spencer for reviewing this report and providing helpful suggestions. We thank Amy Carroll for help in formatting and finalization of this report. Funding for this project was provided by the Southeast Sustainable Salmon Fishery Fund under Project 45215.

REFERENCES CITED

Buckland, S. T. and P. H. Garthwaite. 1991. Quantifying precision of mark–recapture estimates using the bootstrap and related methods. Biometrics 47:255–268.

Clark, J. H., A. Burkholder, and J. E. Clark. 1995. Biological escapement goals for five sockeye salmon stocks returning to the Yakutat area of Alaska. Regional Information Report Number 1J95-16, Alaska Department of Fish and Game, Division of Commercial Fisheries Management and development. Douglas, Alaska 56 pp.

Clark, J. H., G. F. Woods, and S. Fleischman. 2003. Revised biological escapement goal for the sockeye salmon stock returning to the East Alsek–Doame River system of Yakutat, Alaska. Alaska Department of Fish and Game, Special Publication No. 03-XX, Anchorage.

Clutter, R., and L. Whitesel. 1956. Collection and interpretation of sockeye salmon scales. Bulletin International Pacific Salmon Fisheries Commission, No. 9, New Westminster, B.C.

Cochran, W.G. 1977. Sampling techniques, 3rd ed. John Wiley and Sons, Inc. New York. 428pp.

Efron, B., and R. J. Tibshirani. 1993. An introduction to the bootstrap. Chapman Hall, New York. 436 pp.

Goodman, L. G. 1960. On the exact variance of a product. Journal of the American Statistical Association. 66:708–713.

Koo, T.S.Y. 1955. Biology of the red salmon, Oncorhynchus nerka (Walbaum), of Bristol Bay, Alaska as revealed by a study of their scales. Doctoral dissertation, University of Washington, Seattle.

Koo, T.S.Y. 1962. Age Determination in Salmon. Pages 37–48 in Studies of Alaska Red Salmon, T.S.Y. Koo, editor. University of Washington Press, Seattle. Mosher, K. 1969. Identification of Pacific salmon and steelhead trout by scale characteristics. United States Department of the Interior, Circular 317, Washington, D.C.

Mosher, K. 1969. Identification of Pacific salmon and steelhead trout by scale characteristics. United States Department of the Interior, Circular 317, Washington, D.C.

Seber, G.A.F. 1982. On the estimation of animal abundance and related parameters. 2nd. ed. Charles Griffin and Sons, Ltd., London. 654 p.

APPENDIX A

Appendix A 1.– Detection of size-selectivity in sampling and its effects on estimation of size composition.

Results of Hypothesis Tests (K-S and χ^2) on lengths of fish MARKED during the First Event and RECAPTURED during the Second Event	Results of Hypothesis Tests (K-S and χ^2) on lengths of fish CAPTURED during the First Event and CAPTURED during the Second Event
Case I:	
"Accept" H_o	"Accept" H_o
There is no size-selectivity during either sampling event.	
Case II:	
"Accept" H_o	Reject H_o
There is no size-selectivity during the second sampling event but there is during the first.	
Case III:	
Reject H_o	"Accept" H_o
There is size-selectivity during both sampling events.	
Case IV:	
Reject H_o	Reject H_o
There is size-selectivity during the second sampling event; the status of size-selectivity during the first event is unknown.	

Case I: Calculate one unstratified abundance estimate, and pool lengths, sexes, and ages from both sampling events to improve precision of proportions in estimates of composition.

Case II: Calculate one unstratified abundance estimate, and only use lengths, sexes, and ages from the second sampling event to estimate proportions in compositions.

Case III: Completely stratify both sampling events, and estimate abundance for each stratum. Add abundance estimates across strata to get a single estimate for the population. Pool lengths, ages, and sexes from both sampling events to improve precision of proportions in estimates of composition, and apply formulae to correct for size bias to the pooled data (p. 17).

Case IV: Completely stratify both sampling events and estimate abundance for each stratum. Add abundance estimates across strata to get a single estimate for the population. Use lengths, ages, and sexes from only the second sampling event to estimate proportions in compositions, and apply formulae to correct for size bias to the data from the second event.

Whenever the results of the hypothesis tests indicate that there has been size-selective sampling (Case III or IV), there is still a chance that the bias in estimates of abundance from this phenomenon is negligible. Produce a second estimate of abundance by not stratifying the data as recommended above. If the two estimates (stratified and unbiased vs. biased and unstratified) are dissimilar, the bias is meaningful, the stratified estimate should be used, and data on compositions should be analyzed as described above for Cases III or IV. However, if the two estimates of abundance are similar, the bias is negligible in the UNSTRATIFIED estimate, and analysis can proceed as if there were no size-selective sampling during the second event (Cases I or II).

Appendix A 2.– Summary of beach seine sets made, number of sockeye salmon caught, and type of mark employed by date and location.

Set	Date	Start Fishing Time	Number sockeye Caught	Number sockeye Marked	Secondary Mark[a]	Location
1	9-Jul	15:30	18	18	LAUX	regulatory markers
2	9-Jul	17:30	3	3	LAUX	regulatory markers
3	10-Jul	11:30	19	19	LAUX	regulatory markers
4	10-Jul	12:15	4	4	LAUX	regulatory markers
5	10-Jul	12:45	14	14	LAUX	regulatory markers
6	10-Jul	13:50	55	55	LAUX	regulatory markers
7	10-Jul	14:50	3	3	LAUX	regulatory markers
8	10-Jul	15:45	14	14	LAUX	regulatory markers
9	10-Jul	16:20	17	17	LAUX	regulatory markers
10	10-Jul	16:55	6	6	LAUX	regulatory markers
11	14-Jul	15:45	45	44	LAUX	regulatory markers
12	14-Jul	16:55	14	14	LAUX	regulatory markers
13	14-Jul	17:30	6	6	LAUX	regulatory markers
14	15-Jul	12:30	76	76	LAUX	regulatory markers
15	23-Jul	10:50	1	1	RAUX	
16	29-Jul	13:05	272	272	RAUX	Steve's Island
17	30-Jul	10:45	98	98	RAUX	Steve's Island
18	30-Jul	12:50	171	171	RAUX	Steve's Island
19	4-Aug	13:00	176	176	LUOP	Steve's Island
20	5-Aug	10:30	274	274	LUOP	Steve's Island
21	5-Aug	14:40	159	159	LUOP	end of Steve's Island
22	6-Aug	10:45	166	166	LUOP	end of Steve's Island
23	6-Aug	13:25	100	100	LUOP	east shore Steve's Island
24	6-Aug	15:00	98	98	LUOP	east shore Steve's Island
25	13-Aug	13:15	66	66	RUOP	east shore Steve's Island
26	13-Aug	14:45	96	96	RUOP	east shore Steve's Island
27	16-Aug	11:45	51	51	RUOP	Schumacher's Camp
28	16-Aug	14:15	117	117	RUOP	Schumacher's Camp
29	16-Aug	16:05	4	4	RUOP	Schumacher's Camp
30	17-Aug	10:15	321	321	RUOP	Schumacher's Camp
31	18-Aug	10:15	19	19	RUOP	north cove of lake
32	18-Aug	11:00	184	184	RUOP	north cove of lake
33	18-Aug	15:00	35	35	RUOP	north cove of lake
34	19-Aug	10:30	54	54	RUOP	north cove of lake
35	19-Aug	12:15	83	83	RUOP	Schumacher's Camp
36	19-Aug	14:30	131	131	RUOP	Schumacher's Camp
37	26-Aug	14:15	142	142	LUOP & RUOP	Steve's Island
38	27-Aug	12:30	110	110	LUOP & RUOP	Schumacher's Camp
39	28-Aug	10:05	2	2	LUOP & RUOP	Steve's Island
Total			3,224	3,223		

[a]Primary mark is removal of the adipose fin. Secondary marks are indicated by removal of the left axillary process (LAUX), right axillary process (RAUX), or a hole punched in the left upper opercle (LUOP) or right upper opercle (RUOP).

Appendix A 3.– Summary of number of salmon inspected and number marked by date and location, East Alsek River, 2003.

	Number Inspected[a]				Number Marked			
Date	Lower	Middle	Upper	Total	Lower	Middle	Upper	Total
23-Sep		460		460		12		12
24-Sep	91		206	297			4	4
25-Sep		100	20	120		1		1
26-Sep			80	80			3	3
27-Sep		119		119		2		2
29-Sep	108			108	5			5
30-Sep			147	147			3	3
1-Oct		145		145		1		1
2-Oct			103	103			3	3
3-Oct		165		165		6		6
4-Oct	34	61		95	3	1		4
6-Oct		53	36	89			2	2
7-Oct		114		114		5		5
8-Oct	259			259	7			7
9-Oct			235	235			5	5
11-Oct		510		510		12		12
12-Oct	375			375	10			10
13-Oct			163	163		1	6	7
14-Oct		224		224		6		6
15-Oct	146			146	5			5
Total	1,013	1,951	990	3,954	30	47	26	103

[a] River sections sampled are classified as Lower (2.4 Km upriver), Middle (4.8 Km upriver), and Upper (11 Km upriver)

Appendix A 4.– Size stratified age and length composition and escapement by age class for East Alsek River sockeye salmon, 2003.

	Age						
Parameter	0.2	0.3	1.2	0.4	1.3	2.2	Total
Length less than or equal to 560 mm							
Female							
Sample size	47	202	7	1	14		271
% sample	14.7%	63.1%	2.2%	0.3%	4.4%		84.7%
SE[a] % sample	2.0%	2.7%	0.8%	0.3%	1.1%		2.0%
Escapement estimate	6,047	25,991	901	129	1,801		34,869
SE Escapement estimate	1,052	3,085	350	129	509		3,951
Mean Length[b]	507	544	503	525	544		537
SE Length	3	1	5		3		1
Male							
Sample size	14	27	4		3	1	49
% sample	4.4%	8.4%	1.3%		0.9%	0.3%	15.3%
SE % sample	1.1%	1.6%	0.6%		0.5%	0.3%	2.0%
Escapement estimate	1,801	3,474	515		386	129	6,305
SE Escapement estimate	509	744	261		225	129	1,081
Mean Length	504	552	475		550	555	532
SE Length	9	2	11		6		3
Combined							
Sample size	61	229	11	1	17	1	320
% sample	19.1%	71.6%	3.4%	0.3%	5.3%	0.3%	100.0%
SE % sample	2.2%	2.5%	1.0%	0.3%	1.3%	0.3%	0.0%
Escapement estimate	7,849	29,465	1,415	129	2,187	129	41,174
SE Escapement estimate	1,251	3,424	446	129	568	129	4,562
Mean Length	506	545	493	525	545	555	536
SE Length	3	1	5		3		1
Length greater than 560 mm							
Female							
Sample size		58					58
% sample		31.4%					31.4%
SE % sample		3.4%					3.4%
Escapement estimate		25,352					25,352
SE Escapement estimate		5,109					5,109
Mean Length		572					572
SE Length		1					1
Male							
Sample size		122			5		127
% sample		65.9%			2.7%		68.6%
SE % sample		3.5%			1.2%		3.4%
Escapement estimate		53,326			2,185		55,511
SE Escapement estimate		9,507			1,023		9,848
Mean Length		592			597		592
SE Length		2			5		1
Combined							
Sample size		180			5		185
% sample		97.3%			2.7%		100.0%
SE % sample		1.2%			1.2%		0.0%
Escapement estimate		78,678			2,185		80,863
SE Escapement estimate		13,446			1,023		13,785
Mean Length		586			597		586
SE Length		1			5		1

[a]SE - Standard Error of estimate

[b]Mean Length - represents the mean of 5 mm interval measurements.